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THE GREAT NEBULA IN ANDROMEDA.

H. C. WILSON.

If one will look a few degrees to the west of the zenith, at about 9 o'clock on these nights early in December, he will see, near the star ν in the constellation Andromeda, a faint glow; a hazy patch of light, more or less large according to the clearness of the atmosphere, which has often been mistaken for a comet by those unfamiliar with it. It does not appear to have been especially noticed by ancient writers, but was seen and referred to by the Persian astronomer Al-Sûfi in the tenth century. It was first observed with a telescope in 1612 by Simon Marius (Mayer), who described it as a whitish patch brighter at the center and fainter at the edges, "like a candle seen through horn."

This nebula, the most conspicuous in the heavens, has been observed again and again by astronomers and many drawings have been made of it, with the aid of powerful telescopes, but its true shape was not realized until in 1888, when Mr. Isaac Roberts' famous photograph, taken with a 20-inch reflector and 4 hours exposure, brought out the wonderful details of its structure.

In 1847, Professor G. P. Bond, using the 15-inch refractor of Harvard College Observatory, saw two dark rifts along the northwest side of the nebula, which had not before been noticed, but which, once pointed out, were easily seen with even small telescopes. In Bond's drawing the inner of the two rifts has a slight curvature corresponding with the photographs, but he did not catch the turns at the ends and so did not grasp the conception of the spiral character of the nebula. Other observers have usually represented the two channels as perfectly straight. The channels on the southeast side of the nebula had not, to my knowledge, been noticed until the photographs revealed them.

The nebula had been photographed many times previous to 1888, but only the central brighter parts had impressed themselves upon the sensitive plate. Astronomers could see a greater extent of nebulosity with the telescope than could be traced

upon the photographs. Although the nebula is brighter to the eye than the Orion nebula its light appears to be far less rich in photographic rays. Its spectrum differs from most of the nebulae, being continuous from a little below the *C* line to a little above the *F* line, instead of consisting of a few bright lines.

The photograph from which the engravings of the Andromeda Nebula contained in this number of POPULAR ASTRONOMY (Frontispiece and Plate XIII) were prepared, was taken by the writer on the nights of Oct. 4, 5, 6 and 7, 1899. The instrument used was the Clark refractor, with a three lens objective of 8 inches aperture, and the total exposure given was 12 hours.

Plate XIII was prepared from a copy of the original negative on the same scale. The Frontispiece has been enlarged from the original and reduced by the engravers, so that its scale is now about 1.66 times that of the original.

The copies for reproduction have been treated in such a way as to intensify the feeble outer whorls of the nebula at the expense of the details of the central portion. The original negative is a very delicate one, containing a wonderful amount of detail, much of which has been lost in the reproduction. Faint stars and dark irregular holes can be seen in the central part of the nebula to within 1′ of the nucleus. The latter does not appear to be stellar upon this photograph but some negatives with shorter exposures show a decidedly stellar point in the center of the strongest nebulosity. In this picture the nucleus is buried in the glare of the superimposed nebulosity, which the prolonged exposure has made overpowering.

What strikes ones attention particularly, after a first general impression of the gigantic whorls of the nebula, is the crooked, broken, patchy character of the spirals and the channels between them, and the number of very minute stars strung along the spiral streams of nebula, following in general the same crooked alignment and avoiding the dark channels. The outermost whorl on the right hand and at the lower end of the nebula is so broken that one has almost to look with averted vision in order to see that the patches make up a continuous stream. Several of the bright patches, especially at the lower right end of the nebula, show a decided tendency to break up into star clusters. In one, the brightest at the lower right, with an equally large dark patch just below it, the process of star formation seems to be well advanced, there being no less than 50 stellar points to be counted in it. A better confirmation of the Nebular Hypothesis of world formation can hardly be found.

This nebula lies not far from the Milky Way and probably the majority of the brighter stars seen in the photograph have no connection with the nebula, being either nearer or more distant and being seen in it merely as the result of perspective. Allowing however for a number equal to the average seen in equal areas in other parts of the field of the photograph, there are still a large number of faint stars whose association with parts of the nebula is too obvious to admit of much doubt.

The extent of the nebula is enormous beyond conception. The longest diameter of the outer whorl as shown in the engraving is about one and two-thirds degrees, but another photograph, taken with the 2½-inch Darlot lens on the same nights, nearly doubles the length of the nebula, still feebler light extending out to nearly the same distance beyond the ends of the nebula as photographed with the 8-inch refractor. This faint extension is verified on still another photograph taken with the 6-inch Brashear doublet at the same time with the two just mentioned. The impression is not dense enough to show whether or not this outer portion partakes of the spiral character of the inner nebula.

The parallax of the nebula has not been determined, nor is it possible to get more than an approximate maximum value for the parallax. The little stellar point in the center of the nucleus is too faint for satisfactory pointings with the high powers necessary for parallax measures. Also it is uncertain whether or not this star is a part of the nebula or is simply seen in it by perspective. The same difficulty applies to all the stars near enough to the nucleus to be used as comparison stars. All we can say now is that the nebula is probably as distant as the majority of the stars and therefore inconceivably grand in its proportions. Here is apparently a sidereal system by itself in the process of formation. If some ages hence, when the process has gone on toward completion, an observer could take a position in the midst of this great nebula and look outward, the view might not be very different from that which we now see every clear night. One might see there stars of that system scattered over all the sky and, in the direction of the plane of the great spirals, a galaxy of thickly strewn stars like our own Milky Way.

The great nebula evidently lies in a plane which has a small inclination to the line of sight, so that it presents itself edgewise to us. The small nebula in the upper right hand portion of the picture, which was first noted by Miss Caroline Herschel and is known as *HV* 18, is also probably seen edgewise and at a differ-

ent angle from that of the great nebula. There are indications upon two of our negatives that this is a right hand spiral, one whorl issuing from the north of the nucleus, turning to the right and extending down to a small star southwest of the nucleus. This is wholly hidden in the central glare in the engraving. The nucleus of this small nebula is apparently stellar in all our negatives.

The small round nebula, directly south of the center of the great nebula, is known as Messier 32. It is curiously situated at what appears to be the end of the great whorl, but may have no connection whatever with the great nebula. It is slightly elongated north and south, but does not show any evidence of spiral nature. The nucleus is not so plainly stellar as those of the other nebulae.

The bright curve on the left edge of Plate No. XIII is due to the bright star ν Andromedæ, whose light fell upon the side of the tube of the telescope just in front of the plate. Although the tube was blackened, enough light was reflected in 12 hours to produce this crescent and some of the apparent nebulosity near it.

ANCIENT ECLIPSES AND CHRONOLOGY.*

R. W. McFARLAND.

For Popular Astronomy.

The burden of this paper may be taken as a plea for a more critical examination of the historical connection between reported eclipses and events in ancient history:—at least for a more critical estimate than has at times been made. . . . .

In a large work—huge enough apparently to contain all the facts which might claim the attention of mankind,—42 quarto volumes,—I find this assertion; "The world was created Sunday, October 23, 4,004 years B. C.,"—a date sufficiently explicit, it would seem, to satisfy the most exacting inquirer. Another older record puts it a little differently:—"In the beginning God created the heaven and the earth." Which of these is right? or are both in the same category? The one date all intelligent people instantly and utterly reject; to the other, it is hardly possible for the most exacting inquirer to interpose any objection however small.

*[Read before Section A of the Am. A. A. S., at its meeting in Columbus, O., August, 1899.]

PLATE XIII.

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The Great Andromeda Nebula.

From a Photograph by Dr. H. C. Wilson, with the 8-inch Clark Refractor of Goodsell Observatory of Carleton College, Northfield, Minnesota, Oct. 4, 5, 6 and 7, 1899. Total exposure 12 hours.

But when was the beginning? . . . . . .
In reference to dates not so far away, I might quote standard authors, and authors who are not standard, both sets of modern times, who make equally positive assertions as is the first one above, about dates equally uncertain.

It is one purpose of this paper to inquire, as far as the time will allow, what are the foundations on which such statements as the following rest: "Eclipse . . . . observed at Nineveh in the year 763 B. C., between 9 and 10 o'clock on the morning of June 15th." . . . . . .

"At Sardis, April 19, 481 B. C. middle of the eclipse 6^h 9^m A. M. . . . to inquire, in fine, whether there is any foundation or sure ground at all, in which to base *any ancient date whatever.* It is of course known to all intelligent men that we follow, in general, for antiquity, the chronology of Rome. That of the Greek, the Jew, the Egyptian, the Chaldean or Babylonian, is made to conform as far as possible to the Roman standard. I shall speak briefly of two or three of these systems, so as to bring them fairly before you, but only so far as suits my purpose. It is not necessary to go over all of them, or minutely into any.

Our knowledge of Babylonian dates,—astronomical and other,—is obtained from the writings of Berosus. He was a priest of the temple of Belus in Babylon, when Alexander the Great was there, three and a third centuries before Christ. . . . . Authon in his Classical Dictionary, says Berosus "seems to have composed his work with a serious regard for the truth."—We shall see for ourselves presently, how well or ill he succeeds. I suppose that Professor Sayce, of Oxford, England, has been as competent a judge of things Baylonian, as any man who has lived in this century. Speaking of Berosus, he says "His works have unfortunately perished, but the second and third hand quotations" from them "give etc., etc. Numerical figures, however, as might be expected, are untrustworthy." "Second and third hand quotations"! and "untrustworthy numerical figures"! . . to this complexion it has come at *first* not at last.

The ninth edition of the Encyclopedia Britannica says, "The work of Berosus is principally known through the fragments of Polyhistor and Apollodorus. . . . . We are indebted to this work—[that of Apollodorus]—for a knowledge of various important dates, ... the Olympiads," etc., etc.

Now Apollodorus lived nearly two centuries after the time of Alexander. One of his editors says that there remains "a mere fragment of his writings"; and a learned French critic says that

Apollodorus "wrote none of the fragments which are ascribed to him." Polyhistor flourished half a century after the time of Apollodorus, but fares a little better in the hands of the critics.

In order that we may the better see the "serious regard for truth" attributed to Berosus, let us take a few extracts from these "second and third hand quotations." It may be well to bear in mind what the Britannica further says, viz., "There is, however, no probability that any published system has correctly restored the dates of Berosus."

Berosus is made to declare that "the first ten kings"—not dynasties—"of Babylonia reigned 432,000 years";—a generous average of 43,200 years for each. . . . . The next 86 kings held sway for more than 33,000 years,—a modest term for each of a little less than 400 years. Such is the "truth" as set forth by Berosus;—from whom, at second and third hand, come *all our dates for Chaldean eclipses.*

Professor Sayce further says, "Next to Berosus, the authority of Herodotus ranks highest. His information, however, is scanty, and he had to trust to the doubtful statements of Ciceroni." Verily, at this rate, every "second and third hand" quotation will endure as long as the everlasting hills!

I have read in the original nearly all the works of Herodotus, —some parts over and over again,—so that I fully agree with the aforesaid Encyclopedia, when it says, "The masterpieces of Herodotus and Thucydides while setting forth, (each in the manner suited to the author's aim,) events in the order of their succession, are stories without dates." Suppose we question Thucydides. In Book 2, chapter 50, he says "The Moon was eclipsed, for it was the time of the full Moon." This is all that Thucydides says about it. Now tell me what year it was. Again, in Book 4, chapter 52, he says "There was an eclipse at new Moon." And that is the extent of the information which he gives of this event. Let us try again: in Book 2, chapter 28, he says, "At the real new moon (for it seems possible to happen at that time only) the sun was eclipsed after midday, and it again became fully round, certain stars also having shone out."

This is all right, but when was it? Thucydides says no more about it. In only one other place, so far as I remember, is any eclipse mentioned by him. Such are the general facts concerning the only sources of our knowledge of Chaldean astronomy.

Let us see how it fares with the Olympic Period, and with the Founding of Rome, as fixed points of reference.

Herodotus and Thucydides and Xenophon knew nothing of

such an epoch as the Olympiads, how many times soever they may have witnessed and enjoyed the Hellenic games on the bank of the Alpheus. The period in question—the Olympiads—is set at 776 B. C.; but it was not used as a time from which to reckon dates for more than 500 years after that time.

The date for the Founding of Rome is in a worse plight than is that of the Olympiads. Read Niebuhr's History, and see for yourselves what a mass of myths and old men's fables are set forth. In like manner as the Olympiads, the Founding of Rome was not used as an era from which to reckon dates, for more than 500 years subsequent to the alleged time. Besides, what is the alleged date? The first writer of Roman History, Fabius Pictor, puts it in the year which we are accustomed to call 747 B. C. Polybius, a far more able and careful writer, makes it 750; Portius Cato, 751; Flaccus, 752; Varro, 753; and Varro's time is usually followed by men who write about Rome in English. Pictor and Cato flourished about two centuries B. C.; Polybius, a century and a half; Flaccus and Varro, about one century—to give all in round numbers.

Of the Roman writers who flourished about the beginning of the Christian Era, Livy, so far as he uses dates at all, follows Cato, except in a few instances in which he follows Pictor. Dionysius Halicarnassus also follows Cato; while Cicero and Pliny follow Varro. Caesar follows no guide:—he is guide for himself: and in his history of the Gallic war, extending over nine or ten years, he has only three dates, if dates they may be called, that dates are none. In the first book, he mentions the consuls of two different years. The second, third, and fourth books are without dates; the fifth book has one; the sixth and seventh none. . . . . .

In an examination of dates through the two centuries preceding the reformation of the Calendar by Julius Caesar, I have traced carefully, by the names of the consuls, 105 of the 200 years:—all the statements being taken from the same eminent authority. Of these I find seven years with two sets of consuls; four other years, with three sets; four other years still, with four sets; and one year with five sets. Now there was but one set each year: and this doubling, tripling, etc., arises from different writers who disagree about the dates. And if such are the facts with the 250 years just preceding the Christian era, what is sure to follow for centuries still further away?

I quote again from the Britannica, "The absence and incompleteness of authentic records, however, is not the only source of

obscurity and confusion in the chronology of remote ages. One city would reckon by its kings; another, by its magistrates; another, by its priests; and the next not reckon at all." . . . . "Precision, which was at first unattainable for want of an epoch, was afterwards no less unattainable from their multiplicity and sometimes from the variatious of the [same] epoch."

The London Cyclopedia, many years ago, gave a list of ancient eclipses supposed to contain all referred to by any ancient writer. The list contains 20 eclipses of the Sun and 9 of the Moon. I have already mentioned what Thucydides says of three or four cases. But not to dwell longer on this part of the subject, I will close it by a couple of quotations from a great master of the question, Sir John Herschel. He says, "According to the Augustan reform, the years A. U. C. 761, 765, 769, etc., which we now call A. D. 8, 12, 16, etc., are leap years. And starting from this as a certain fact, (for the statements of the transaction by classical authors are not so precise as to leave *absolutely no doubt* as to the previous intermediate years,) astronomers and chronologists have agreed to reckon backwards in unbroken succession on this principle, and thus to carry the Julian chronology into past time, *as if* it had never suffered such interruption, and *as if* it were certain;—(which it is not, though we believe the balance of probabilities to incline that way.")

These underscored *as ifs* rule all certainly out of court, in Sir John's estimation.

Again: "It is fortunate for astronomy that the confusion of dates, and the irreconcilable contradictions which historical statements too often exhibit, when confronted with the best knowledge we possess of the ancient reckonings of time, affect recorded observation but little. An astronomical observation of any striking and well-marked phenomenon, carries with it in most cases abundant means of recovering its exact date, when any tolerable approximation is afforded to it by chronological records. . . . . Remarkable eclipses, for instance, now that the lunar theory is fully understood, can be calculated back for several thousand years, without the possibility of mistaking the day of their occurrence. And whenever any such eclipse is so interwoven with the account given by an ancient authority, of some historical event, as to indicate precisely the interval of time between the eclipse and the event, and at the same time completely to identify the eclipse, that date is recovered and fixed forever."

This is powerfully and lucidly stated, and we may consider it

as embracing all "the law and the prophets,' on the subject. Let us see how the account stands in the records.

In a foot note to this extract from Herschel, he says, "See the remarkable calculations of Mr. Baily relative to the celebrated solar eclipse which put an end to the battle between the kings of Media and Lydia, B. C. 610, September 30."

Whewell, in his History of the Inductive Sciences, says, "The eclipse of Thales is so remarkable a point in the history of astronomy and has been the subject of so much discussion, that it ought to be more especially noticed." He then refers to the "Philosophical Transactions for 1853," which contains Sir George Airy's account or history of the case, together with the results of his own computation, viz., "May 28, 585 B. C."

Mr. Martin, a French historical critic, does not manifest a very cordial belief that Thales made his prediction before the event. He says, "Even if Thales did make such a prediction before the event, as he might have done by the Chaldean period of 18 years," (had he known anything of such a period,) he would have had to take the chance of its being visible in that locality." Further, Mr. Martin says, "That no (ancient) author claims that Thales or his successors, Anaximander and Anaxagoras, ever tried their luck in the same way again,"—but that, on the contrary, "we are told that the "two latter astronomers, *in revenge*, predicted, the one an earthquake, and the other, a fall of meteorites, which latter predictions are plainly fabulous, although as well attested as in the eclipse of Thales."

The whole history of this celebrated eclipse is based on two or three sentences in the 74th chapter of the first book of Herodotus. Here they are: "In the sixth year a conflict took place; and on the battle being joined, it happened that the day suddenly became night, and this change Thales of Miletus had predicted to them, definitely naming this year, in which the event actually took place. The Lydians and Medes when they saw day turned into night, ceased from fighting, and both sides were desirous of peace." And this is all there is of it.

I suppose that no two men within the century past, have been better able to fix the date of this eclipse than Sir Francis Baily and Sir George Airy;—the latter for nearly half a century being Astronomer Royal. The first made it September 30, 610 B. C., the other, May 28, 585 B. C., a discrepancy of nearly 25 years. James Ferguson, the Scotch astronomer, with his ingenious mechanical devices, made it May 18, 603.

Of course what non-mathematical writers may say is not

likely to weigh very heavily against the results of competent astronomers, still let us look a little at this side of the question, since expert astronomers differ so widely.

In his history of astronomy, Grant says that Cicero and Pliny put the eclipse in the first year of the 48th Olympiad, or 585; Scaliger made it October 1, 583; Archbishop Usher, 601; Bayer and others, 603. In Rawlinson's History we find 584 as the year of Pliny, differing one year from Grant; Clemens Alexandrinus, 579. Of modern historians, Volney says 625; Lardner 597; Clinton, 603; Ideler and Groto, 610. Bosanquet, 583; Oltmann, after due computation, 610.

Here we have ancients and moderns, historians and mathematicians,—English, German, French,—asserting in words as positive as the English language affords, that this eclipse took place at 9 different dates, scattered over 46 years of time; while the two men most competent to form an opinion, differ by nearly 25 years. Is the date of this eclipse "fixed forever?"

I repeat the criterion of Sir John Herschel, "Whenever any such eclipse is so interwoven with the account given by an ancient authority, of some historical event, as to indicate precisely the interval of time between the eclipse and the event, and at the same time completely to identify the eclipse, that date is recovered and fixed forever."

Of the list of eclipses given in the London Cyclopedia, scarcely half a dozen have any asserted or plausible connection with any other recorded event. You have seen how it fares with the most celebrated of all. How far then has the record of eclipses aided men in their chronology? What inference do you draw? There can be but one,—"There is no New Light from Old Eclipses."

TO PHOTOGRAPH THE SOLAR CORONA IN 1900.

W. W. PAYNE.

In a late number of the *Oakland Inquirer*, we find a pretty full statement of the preparations of Charles Burckhalter, director of the Chabot Observatory, at Oakland, Cal., for the expedition which he has organized to observe the total solar eclipse of May 28, 1900. In the last number of this publication, will be found a large plate, as frontispiece, which shows the full length and width of the track of totality, to scale, as it passes over the southern part of the United States. Mr. Burckhalter's point of observation for his party is somewhere in the State of Georgia.

The particular reason for calling attention to the work of this expedition is to speak of the novel photographic instrument that Mr. Burckhalter is expecting to use on that occasion.

Some time ago Mr. Burckhalter believed that he had devised a plan which would materially assist astronomers in photographing the solar corona in regard to regulating the exposure of the sensitive plate for exterior and interior portions of it. So far, by the ordinary methods of photographing this delicate and most beautiful phenomenon, it has been quite impossible to secure on the same plate the wonderful detail of the inner corona and also the faint exterior streamers which make up the outer corona. The reason for this photographers well understand and any one may easily realize, when it is said that the time of exposure of any object depends on its brightness. The brighter the object the shorter should be the time of exposure to get its structure in full detail. If the exposure of a bright object, like the full Moon, is too long the light portion of the surface will be covered with blotches of light, in which most of the interesting detail is lost. In the darker parts of the surface, for example, the seas, more detail will appear for the simple reason that such parts need longer exposure to bring the detail desired.

This is the main point on which Mr. Burckhalter has been working in relation to photographs of the solar corona. The corona of the Sun as seen in the period of totality in an eclipse is pearly white in color, even brilliantly so, and extends outward from the Sun in all directions to a distance of one-half of the solar diameter and also in some directions much further, in the form of streamers that gradually become fainter until lost entirely in the dark sky at a distance of two or three diameters of the Sun.

That part of the corona which lies near the Sun is intensely bright, and made up of varied and delicate structure so complex, distinct and impressively beautiful that the astronomer longs to have some means to get and keep the charming picture always. Then when the eye is turned to the outer corona and its streamers the brightness diminishes so rapidly that the contrast is very marked, and the great difficulty of photographing both parts of it on the same plate at once immediately appears. The apparatus devised by Mr. Burckhalter to overcome this very troublesome condition consists of two telescopes, one known as the Pearson photographic telescope and the other as the Pardu lens The focal length of the Pearson lens is said to be fifteen feet. The manner of mounting the telescopes is not fully enough stated so as to give a clear idea of this part of the preparation. The aim

appears to be to have the two tubes of the telescopes so related. that photographs by them both may be taken in duplicate under the same conditions if so desired. The special device for work on the corona in the brief period of totality, has for its object the exposure of the sensitive plate in such a way that each part shall have the right time limit. In this way, it is expected that the interior corona will not be over exposed, nor its exterior parts under exposed, a result which every astronomer may well hope can be secured. This carefully graduated exposure is to be effected by means of a diaphragm, revolved by clock-work before the sensitive plate which will vary the time of exposure for different parts of it from two hundreds of a second to ten seconds of time, or, for other differences of time as desired. If such an arrangement for using the varying intensities of the light of the corona can be gained successfully, very interesting results ought to be secured. The period of totality in this eclipse will be only 86 seconds and the width of the black path on the Earth's surface about 40 miles. This very short time of totality will afford observers scant opportunity to do the many things planned for, yet astronomers have learned to work more rapidly in later years and the improved apparatus now in use will make up to some extent for lack in length of totality.

The things to be attempted during the total solar eclipse in May 1900, are a photographic search for intra mercurial planets, and a study of the brightness of the sky. Professor W. H. Pickering is reasonably sure that a body the size of an average asteroid, say 20 miles in diameter, within 15,000,000 of miles of the Sun would show on photographic plates he uses. It is encouraging to know that astronomers do not give up the search for these small bodies near Sun although work during the past twenty years in this direction has not been successful. Another thing is the study of the details in the structure of the corona. The photographic work already spoken of may aid materially in this, but there is also need of careful visual work with good telescopes, in this country, Spain and Portugal for the sake of comparing results obtained from the same kind of work in a prearranged programme. This idea seems to be in considerable favor with those using the telescope chiefly.

One astronomer suggests the desirability of measuring the "rate at which the radiating power of the solar atmosphere is diminished with the altitude above the photosphere and to obtain a rough quantitive comparison with photospheric radiation." Other themes are the lower red in the spectrum, the

"flash spectrum," work with the photometer and the polariscope. Though the time of the eclipse be short it is probable that many American parties will participate in the observation and if the day be a favorable one, some useful results will be expected.

REPORT ON PROGRESS IN NON-EUCLIDEAN GEOMETRY.*

GEORGE BRUCE HALSTED.

Under the title 'Universal Algebra,' one would scarcely look for a treatise on non-Euclidean geometry. Yet the first volume of Whitehead's admirable work (Cambridge 1898, pp. 586) devotes more than 150 pages to an application of Grassmann's Calculus of Extension to hyperbolic, elliptic, parabolic spaces. So devoted is he, that we find him saying: "Any generalization of our space conceptions, which does not at the same time generalize them into the more perfect forms of hyperbolic or elliptic geometry, is of comparatively slight interest." He emphasizes the fact that the three dimensional space of ordinary experience can never be proved parabolic. "The experience of our senses, which can never attain to measurements of absolute accuracy, although competent to determine that the space-constant of the space of ordinary experience is greater than some large value, yet cannot from the nature of the case, prove that this space is absolutely Euclidean."

From the many important contributions by Whitehead may be singled out as especially timely his development of a theorem of Bolyai János to which F. S. Macauly called especial attention in the second of his able articles entitled, John Bolyai's 'Science Absolute of Space' (*The Mathematical Gazette*, No. 8, July, 1896, pp. 25–31; No. 9, October, 1896, pp. 49–60). Macauly says, p. 53, "Finally follows a theorem (§ 21), which is, undoubtedly, the most remarkable property of hyperbolic space, that the sum of the angles of any triangle formed by *L*-lines on an *F*-surface is equal to two right angles. On this theorem Bolyai remarks: (Halsted's Bolyai, 4th Ed., p. 18), 'From this it is evident that Euclid's Axiom XI., and all things which are claimed in geometry and plain trigonometry hold good *absolutely* in *F*, *L*-lines being substituted in place of straights. Therefore, the trigonometric functions are taken here in the same sense (are defined here to have the same values) as

* Continued from page 490.

in Σ (as in Euclidean geometry); and the periphery of the circle of which the L-form radius $= r$ in F, is $= 2\pi r$, and likewise the area of circle with radius r (in F) $= \pi r^2$ (by π understanding half the periphery of circle with radius 1 in F, or the known 3.1415926 * * *).'"

Whitehead, in his Universal Algebra, § 262, recurs to this important point saying: "The idea of a space of one type as a locus in the space of another type, and of dimensions higher by one, is due partly to J. Bolyai, and partly to Beltrami. Bolyai points out that the relations between lines formed by great circles on a two-dimensional limit-surface are the same as those of straight lines in a Euclidean plane of two dimensions. Beltrami proves by the use of a pseudosphere, that a hyperbolic space of any number of dimensions can be considered as a locus in Euclidean space of higher dimensions. There is an error, popular even among mathematicians, misled by a useful technical phraseology, that Euclidean space is in a special sense flat, and that this flatness is exemplified by the possibility of a Euclidean space containing surfaces with the properties of hyperbolic and elliptic spaces. But the text shows that this relation of hyperbolic to Euclidean space can be inverted. Thus no theory of the flatness of Euclidean space can be founded on it." Whitehead has since followed up his point in a very important and powerful paper in the *Proceedings of the London Mathematical Society*, Vol. XXIX., pp. 275–324, March 10, 1898, entitled 'The Geodesic Geometry of Surfaces in non-Euclidean Space.' He there says, "The relation between the properties of geodesics on surfaces and non-Euclidean geometry, as far as they have hitherto been investigated, to my knowledge, are as follows:

"It has been proved by Beltrami that 'geodesic geometry' of surfaces of constant curvature in *Euclidean* space is the same as the geometry of straight lines in planes in elliptic or in hyperbolic space, according as the curvature of the surface is positive or negative.

"The geometry of great circles on a sphere radius ρ in elliptic space of 'space constant' γ is the same as the geometry of straight lines in planes in the elliptic space of a space-constant $\gamma \sin \frac{\rho}{\gamma}$.

"The geometry of great circles on a sphere of radius ρ in hyperbolic space of 'space-constant' γ is the same as the geometry of straight lines in planes in elliptic space of space-constant $\gamma \sin h \frac{\rho}{\gamma}$.

"The geometry of geodesics (that is, lines of equal distance), on a surface of equal distance, σ, from a plane in hyperbolic space of space constant γ, is the same as that of straight lines in planes in hyperbolic space of space constant $\gamma \cos h\frac{\sigma}{\gamma}$.

"Finally, the geometry of geodesics (that is, limit-lines), on a limit surface in hyperbolic space—which may be conceived either as a sphere of infinite radius or as a surface of equal, but infinite, distance from a plane—is the same as that of straight lines in planes in Euclidean space.

"The preceding propositions are due directly, or almost directly to John Bolyai, though of course, he only directly treats of hyperbolic space.

"From the popularization of Beltrami's results by Helmholtz, and from the unfortunate adoption of the name 'radius of space curvature' for γ (here called the space-constant), many philosophers, and, it may be suspected from their language, many mathematicians, have been misled into the belief that some peculiar property of flatness is to be ascribed to Euclidean space, in that planes of other sorts of space can be represented as surfaces in it. This idea is sufficiently refuted, at least as regards hyperbolic space, by Bolyai's theorem respecting the geodesic geometry of limit surfaces. For a Euclidean plane can thereby be represented by a surface in hyperbolic space.

"It is the object of this paper to extend and complete Bolyai's theorem by investigating the properties of the general class of surfaces in any non-Euclidean space, elliptic or hyperbolic, which are such that their geodesic geometry is that of straight lines in a Euclidean plane.

"Such surfaces are proved to be real in elliptic as well as in hyperbolic space, and their general equations are found for the case when they are surfaces of revolution.

"In hyperbolic space, Bolyai's limit-surfaces are shown to be a particular case of such surfaces of revolution. The surfaces fall into two main types; the limit surfaces form a transition case between these types. In elliptic space there is only one type of such a surface of revolution.

"The same principles would enable the problem to be solved of the discovery in any kind of space of surfaces with their 'geodesic' geometry identical with that of planes in any other kind of space."

So that which Macaulay designated as 'undoubtedly the most remarkable property of hyperbolic space' has been by Whitehead

not only generalized for hyperbolic space but extended to elliptic space.

Bolyai János seems fully to realize the weight, the scope, the possibilities, the meaning of his discovery. He returns to it in § 37, where he uses the proportionality of similar triangles in F to solve an essential problem in S (hyperbolic space). Then he adds: "Hence easily appears (L-lines being given by their *extremities alone*) also fourth and mean *terms* of a proportion can be found, and all geometric constructions which are made in Σ in plano, in this mode can be accomplished in F *apart from Axiom XI.*" The italics are Bolyai's, yet I find that they have not been reproduced in my published translation (the only one in English), nor in Frischauf's German, nor in Hoüel's French, nor in Fr. Schmidt's Latin text, nor in Suták's Magyar. Whitehead's researches will remind us all how great a thing it was to have reached the whole Euclidean system entirely apart from any parallel-postulate. It is a pleasure to be able to state that this was also done by Lobachévski. It is explicitly given in his first published work 'O nachalah geometri' (1829). 'Noviya nachala geometri' (1835), devotes to it Chapter VIII.

It is also at this point, so striking as pure mathematics, that general philosophy finds itself involved. Killing, Klein, and in general the German writers, distinctly draw back from any philosophical implications. The whole matter, however, has been opened in 'An Essay on the foundations of Geometry,' by Hon. Bertrand A. W. Russell, Fellow of Trinity College, Cambridge (1897), who has had the good fortune to be the very first to set forth the philosophical importance of von Staudt's pure projective geometry, which in its foundation and dealing with the qualitative properties of space involves no reference to quantity. I discussed this point more than twenty years ago in the *Popular Science Monthly*, *à propos* of Spencer's classification of the Abstract Sciences.

In a note to the first edition of his classification of the sciences (omitted in the second edition), Spencer says, "I was ignorant of this as a separate division of mathematics, until it was described to me by Mr. Hirst. It was only when seeking to affiliate and define 'Descriptive Geometry' that I reached the conclusion that there is a negatively-quantitative mathematics as well as a positatively-quantitative mathematics." As explanatory of what he wishes to mean by negatively-quantitative, we quote from his Table I.: "Laws of Relations, that are quantitative (Mathematics), Negatively: the terms of the relations being

definitely-related sets of positions in space, and the facts predicted being the absence of certain quantities ('Geometry of Position')." He also says: "In explanation of the term 'negatively-quantitative,' it will be sufficient to instance the proposition that certain three lines will meet in a point, as a negatively-quantitative proposition, since it asserts the absence of any quantity of space between their intersections. Similarly, the assertion that certain three points would always fall in a straight line is 'negatively-quantitative,' since the conception of a straight line implies the negation of any lateral quantity or deviation." But Sylvester has said of this very proposition that it refers solely to position, and neither invokes nor involves the idea of quantity or magnitude." (TO BE CONTINUED.)

NON-APPEARANCE OF THE EXPECTED LEONID SHOWER.

WILLIAM H. PICKERING.

FOR POPULAR ASTRONOMY.

Cometary orbits are liable to large perturbations due to the action of the planets. In the case of the orbit of a meteor swarm great uncertainties in these perturbations are liable to occur, owing to the fact that we do not know the precise portion of the orbit in which the swarm is situated. This seems to have been the difficulty with the computations of the present year. The fundamental data on which the computations were based were inadequate. The observations of the scattered meteors actually made this year will give us little assistance in correcting the results derived from these computations, otherwise than to show the general fact that they were incorrect. Such being the case the following considerations based on well known facts may be of some interest.

The first recorded appearance of the Leonid shower was in October, 902, which year was known as "the year of stars." Omitting the mid-century appearances, the shower was again observed in 1002, 1101, 1202, and not again until 1602. After that date a marked perturbation in the orbit occurred, and the shower reappeared four years ahead of time, in 1698. Since this date it has appeared with considerable regularity at intervals of 34 years. We have no record of the next two showers, but a brilliant reappearance occurred 101 years later in 1799. After 34 years came the great shower of 1833 which was followed 34

years later by that of 1867. Showers were also observed in 1866 and 1868. Local evidence seems to point to the fact that the last of these was the finest of the three. although since it was unexpected, it did not happen to be carefully observed by astronomers generally, and is therefore comparatively unknown. Adopting 1867 however as the main shower, and adding 34 years to it, we find that if the shower appears as it has ever since 1698, we should expect to observe it not in 1899, but in 1901. Certainly from this point of view we had little reason to expect it to put in an appearance before 1900, and if we adopt 1868 as the main shower of that series, the finest exhibition of the present series may not occur before 1902.

November 20, 1899.

THE LEONIDS OF NOVEMBER 1899.

W. W. PAYNE.

To say that every one interested in, or having knowledge of, the expected shower of the Leonids for this year was disappointed in what was observed, is to put the matter mildly so far as we can learn ten days after the event. As a consequence many people are asking about the Leonids and the great shower, why it did not appear, and many other questions of similar import. It is probable that more has been said about the return of the Leonids in 1899 during the last few years, than about any other astronomical theme in a score of years. Because the daily papers, scientific journals and the popular magazines have recently made full and frequent reference to the return of this great meteor shower in November of this year, there was rightly very general expectation that a grand display would appear and that everybody who knew of the fact was anxious to observe it. The wonderful shower of the Leonids in 1833 witnessed in the eastern and southern parts of the United States, and the equally grand one seen in England and on some parts of the continent in 1866 have again and again been rehearsed to call attention to the approach of the third and last great shower of the Leonid stream in the present century. During the last thirty years astronomers have given more or less attention to a study of the path of this swarm of meteors in order to determine its course through the solar system that predictions concerning it might be as definite and reliable as possible. Soon

after 1835 astronomers in America recognized the fact that clouds of meteoric particles were revolving around the Sun in the same way as comets and planets do,—in regular orbits, susceptible of calculation. Professor Ohnsted, of Yale College, New Haven, thus early characterized these clouds of meteors as comets. He spoke then, in prophetic way, more than he knew. In 1864, Professor Newton, of New Haven, after some study of the records of meteors showed that there had been a number of great autumn star-showers at intervals of about 33 years, and he announced that another would appear in 1866 or possibly at other dates named. In this view Professor Adams, of Cambridge, England, shared making the period of the return more definite and limiting it to the autumn of 1866. At this time Oppolzer announced the orbit of Tempel's comet of 1866 which was found to agree with the path of the Leonid stream of meteors, the second instance then known of a comet and a cloud of meteors moving in the same orbit.

Astronomers have since learned that this relation between comets and meteors is more general, and so the fact is turned to account in the relation of particular comets to individual meteoric streams, as to their respective places in the common path, and also respecting the age of the meteoric swarm as related to that of its accompanying comet. It is an interesting fact that the two comets associated with the Leonids and the Andromedes are in advance of the meteor-streams in the respective orbits to which they belong. One of the important questions which has occupied the attention of writers on meteoric astronomy is, which is older and the cause of the other, the meteoric cloud or the comet? Some writers of acknowledged authority hold that the meteoric cloud is the result of the disintegration of the comet, and the scattered particles that remain form a stream more or less compact in the path according to the tide-producing effects of the planets and the Sun in the course of time. This idea has been strengthened by the history of Biela's comet and its associated swarm of meteors known as the Andromedes. The common belief although not proved is, that the Biela comet has been completely dissolved and that some of its pulverized remains are now seen in the Andromedes which are supposed to occur Nov. 24 to 27 each year, somewhere, but in a shower of considerable strength, once in thirteen years.

These things are said about meteor swarms to show what interest astronomers have felt lately in the study of this class of

celestial objects and their phenomena, and to indicate how easy it has been to arouse large expectation in the public mind, when a prediction is made of an unusual occurrence of this kind, such as a brilliant meteoric shower. It must be confessed too, that the definite way in which the predictions have been made by astronomers for the last two years has justified large expectations on the part of the general public that these predictions would be fulfilled. Now, anyone has a right to ask why the Leonid display did not occur as predicted? Were the computers wrong? Or has something taken place recently to divert the shower from its path more or less well known for the last thirty years? The queries and others like them must be answered. Astronomers will answer them as soon as reliable data can be secured for the purpose if it is not already in hand.

Last month we mentioned a number of minor difficulties which the computers tried to overcome as far as possible, before conclusions could be reached for the predictions that were made. These uncertainties do not seem to be sufficient in kind or degree to to have changed the path of the stream so much as to make the expected shower an impossibility, unless the stream is largely bunched and the computers have misjudged regarding the position of the main swarm. If this should be true the calculations in regard to disturbance of the path might be seriously in error.

It will be quite readily understood by anyone who will take the trouble to think about it, that if the parent swarm was either much ahead or behind the supposed positions while passing near Saturn in 1870 and also while near Jupiter in 1898, quite different results would have been found as a means to modify the predicted time of display so as to make it earlier or possibly later and *possibly* to so change the path of the whole stream as to throw it out of view entirely. This last result is not probable because a few Leonids have been seen very generally where clear skies favored observation on Nov. 13-16. The bare probability that the main shower may have come a few days earlier than expected has some support from the reports that have come to our notice, that "many meteors" were accidentally noticed by those who were not watching for them on Friday evening, Nov. 10. From these reports, however, we can gain no knowledge that those seen were Leonids, so it might easily happen that those observed were individual meteors from other active radiants in the month of November. It must also be remembered that the predictions of last year were not fulfilled, the maximum of the shower was on the morning of the 15th of No-

vember instead of the 16th as was announced. This fact, however, had its influence undoubtedly in the make-up of the prediction of this year. As a mere suggestion which we have not yet the data to verify, we have thought of a change of the inclination of orbit and a shifting of perihelion point to the eastward so that the point of contact of the Earth's path with that of the meteor stream would be further westward than in previous years. This would cause the display to come earlier than later as predicted for the last two years. In making this suggestion we are aware that computers generally take the opposite view, that the perihelion of the path of the swarm is moving eastward and that the result of such motion is to make the display of meteors come later year by year, the fact that the swarm is accelerated or retarded in its motion by the attraction of the planets could not make much difference in the time of display, if any, because the stream is so long. Such action would rather tend to spread out the group or make it more compact instead of changing its time of appearance.

A glance at results so far as they are known plainly shows how weak the Leonid shower was. At Harvard 50 were seen, Chicago 30, Denver, in 15 minutes before 2 A. M. 18, Kansas City, a fairly large number, Wichita, a few, Princeton, no general shower, Naval Observatory, Washington, D. C., few only, Minneapolis a scant number, Northfield 20, impossible to photograph any at Northfield or Minneapolis. Greenwich, England, only a few observed, Berlin, a considerable shower, India, a small number. In Russia the expectation of the shower caused panics in some places. Churches were open all night and it is said hundreds of thousands spent entire nights in the open air for fear of earthquakes and other calamities expected at the end of the world. The papers also give a novel account of a party of two ascending in a balloon to get a better view of the meteors. The ascent was made at Newbury, Berkshire, England, five meteors were seen, but the observers were obliged to make a sudden descent because the balloon was drifting seaward and the result was that one of the party was badly shaken up and the other suffered a broken arm.

From the above data it will be seen that the results by counting or photographing of the meteors was very disappointing. Still another way of getting more definite results is by platting those meteors which were well enough seen to be drawn on a chart previously prepared for that purpose. Great pains was taken in making a chart of stars including boundaries for the

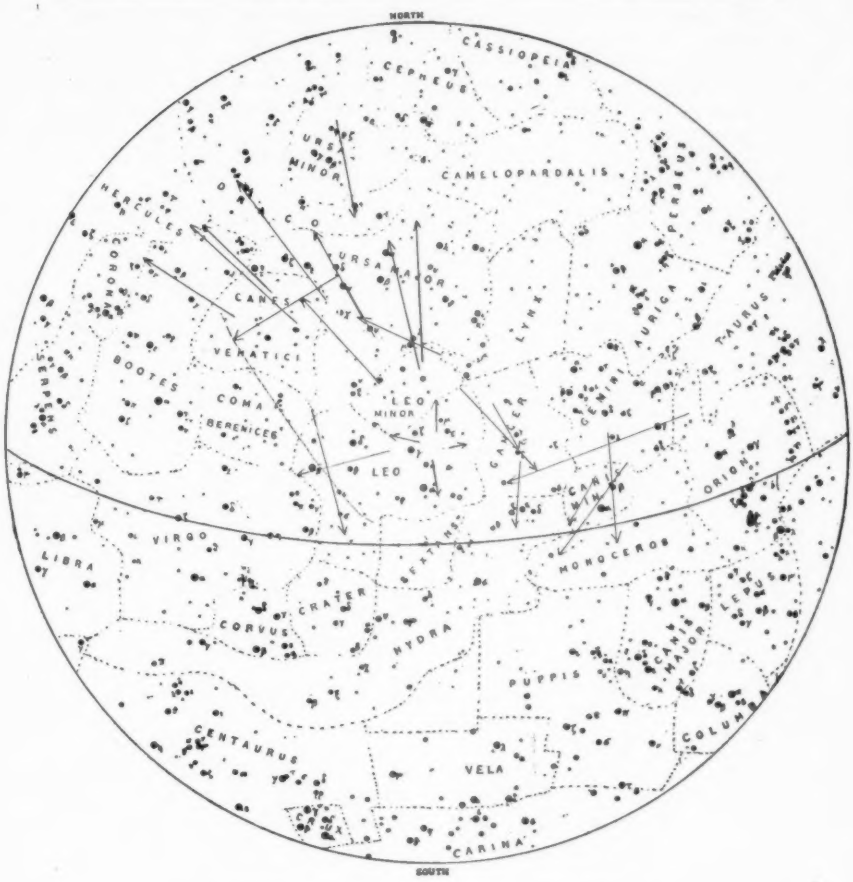
constellations, with mathematical accuracy, having the constellation of Leo which contains the radiant in its center. These charts were distributed very generally to those supposed to be interested in the watch for the Leonids. We give below some of the charts received in time for appearance in this number, with brief references to them in way of explanation by the observers respectively.

Report of observations made at the Buffalo Normal School Observatory on Nov. 13–16, 1899, by M. A. G. Meads, Mr. Howard, assistant, and Mr. Koons, student.

Time—Astro'l.	No.	Color.	Mag.	Remarks.
Nov. 13, 1899				Entirely cloudy.
Nov. 14, "				Mr. Howard and myself only tonight.
From 12:20 to 12:30	1	yellow	2d	Parallel to β—α Canis Min.—See map.
12:45	2	1 yel.		
		1 redish	2d	Passing between μ and λ Ursæ Maj. See map—fog.
13:00				Rested. Clouds and fog.
" 13:00 " 13:15	1			" " " " No stars.
13:30	3	bluish		Enough seen for mapping.
13:45	0			
				No stars on account of clouds.
Nov. 15.				
From 12:30 to 12:45	0			
13:00				Did not watch this period. Clouds.
13:00 " 13:15	8	2 yel.	3d to 4th	Part of sky clear. Floating clouds.
	5	bluish	3d to 4th	Leonids.
	1	redish	3d to 4th	From direction of Androm. through Dipper.
13:30	6	4 yel. 2 bl.		Clouds to the height of 25°.
13:45	4	3 yel. 1 bl.		Fleecy clouds passing.
14:00	5	2 bl.		Clouds filling ¾ of region watched.
14:50				Rested. No stars seen on acc't of clouds.
15:00	11			8 Leonids. Sky clear W. of Leo.
15:15	10			9 "
15:30	8			5 " Fleecy clouds.
15:45	8			5 " " "
16:00	12			8 " " "
16:15	7		1 1st	1 with zig-zag course. 4 Leonids. Clouds until daylight.
Nov. 16.				I watched alone.
From 12:00 to 14:15	0			Partly cloudy. Watch continued as above.
14:30	3	2 white	1st to 2d	Passing near β Canis Min. See map. Not Leonids.
	1		Not more than 5th	½ way between Regulus and Castor. See map. Not a Leonid.
14:45 to 15:15	0			Very clear sky.

Total number of Leonids, 52.

M. A. G. Meads, Teacher of Math. and Astro., Normal Sch.



METEORS CHARTED DURING THE LEONID SHOWER.

Nov. 13—16, 1899 by Mr. M. A. G. Meads, Mr. Howard, assistant, and Mr. Koons, student, at the Normal School Observatory, Buffalo, N. Y.

LEONIDS AT WILTON JUNCTION, IOWA.

The following chart shows the meteors observed by me at Wilton Junction, Iowa, on Nov. 15, 1899, from $18^h\ 30^m$ to $23^h\ 15^m$ G. M. T. On all the other nights the sky was completely obscured by clouds.

The smaller circle is the radiant of all the Leonids observed except the one in Coma Berenices. This one necessitated the drawing of the larger circle. There is a short path traced in Cancer near α Cancri. The path of this meteor was so short and its exact direction so much in question that one would not be justified in considering it a Leonid. The other paths are much more accurate.

The only meteor attracting especial attention was the one in Canes Venatici which had a very much curved path. It appeared at $20^h\ 12^m$ G. M. T., was of a white color and of the first magnitude.

The sky was frequently obscured by clouds during the time of observation and was more or less hazy all the time. This in part, at least, accounts for the few meteors seen.

This was my first attempt at locating a radiant-point by observation and so the results are not as trustworthy as if I had been more experienced.

EDWARD A. FATH.

MUSCATINE, Iowa, 112 W. 5th St.

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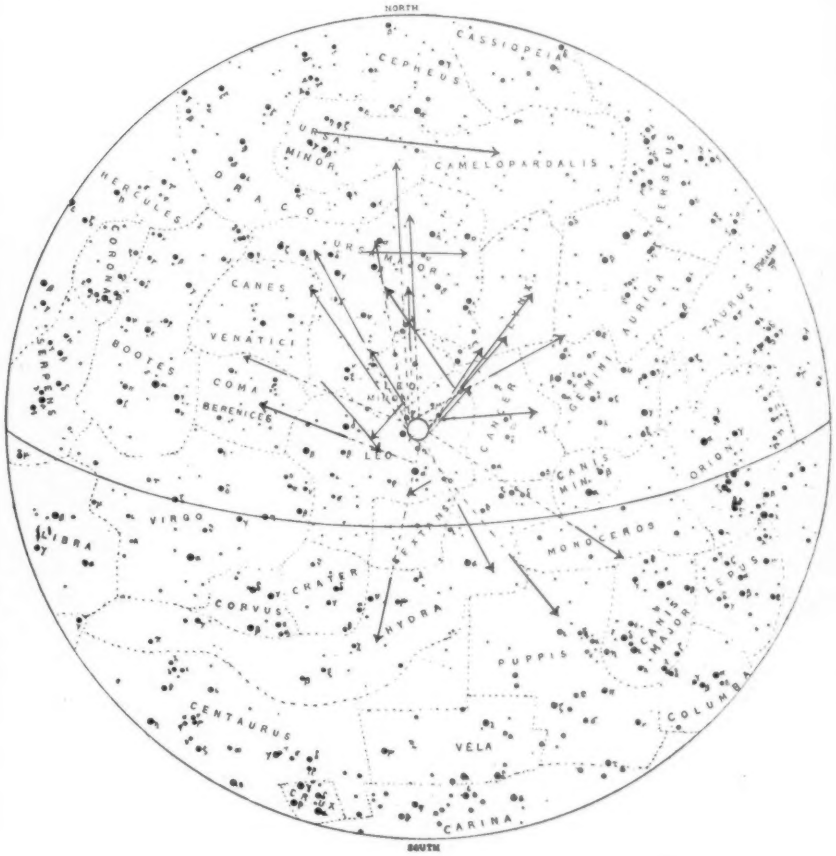
Observations of Leonids at Hanover, Indiana, by Glen Culbertson and his astronomy class.

The accompanying chart is the record made on Tuesday morning, Nov. 13, between 15^h and 16^h 45^m in which some twenty meteors were seen. Wednesday, Thursday and Saturday mornings were cloudy. Seeing imperfect on Friday but no Leonids were seen.



METEORS CHARTED DURING THE LEONID SHOWER.[1]

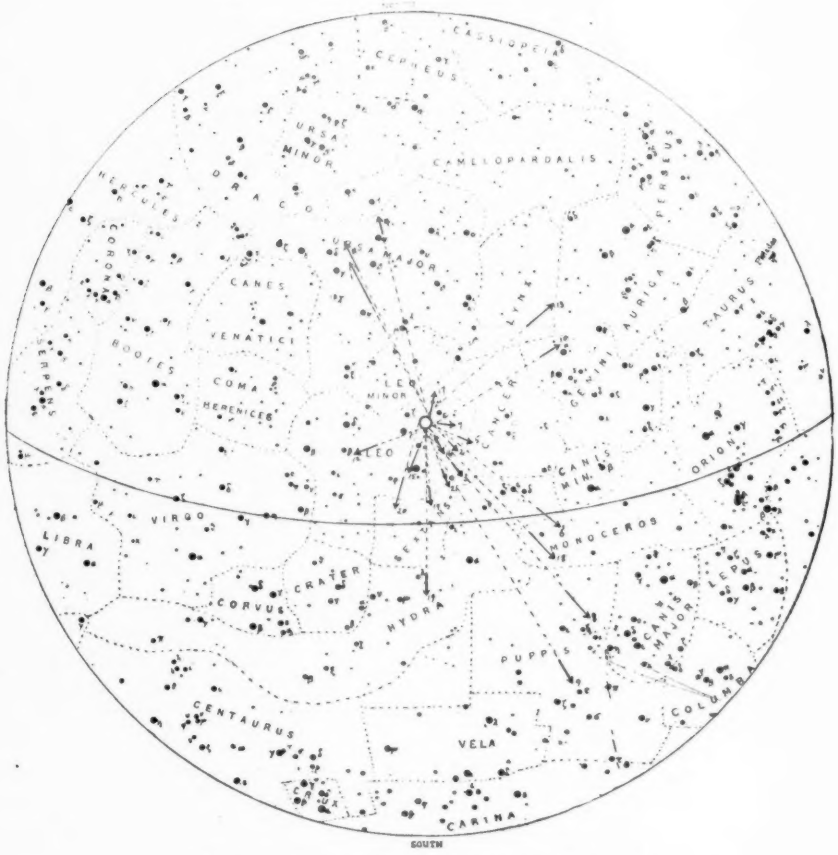
Nov. 13, 1899, 21^h—22^h 45^m Greenwich M. T., by Professor Glenn Culbertson and students at Hanover College, Hanover, Ind.

Observations of Leonids at Mt. Holyoke College Nov. 15, 1899, South Hadley, Mass., by Miss Anne S. Young and Miss Lester.

Time.	Count of Leonids. Leonids.	Others
3:30 to 3:45	2	1
3:45 " 4:00	2	2
4:00 " 4:15	1	1
4:15 " 4:30	3	2
4:30 " 4:45	7	0
4:45 " 5:00	2	0
5:00 " 5:16	4	0
5:40	1	0
	22	6

Max. 4:30 to 4:45 7 Leonids

		L.	Others.
Nov. 10	1:30 to 2:30 A. M.	0	0
" 12	1:30 " 3:00 " "	2	4
" 14	1:30 " 2:30 " "	2	2
" 17	12:30 " 2:00 " "		0



METEORS CHARTED DURING THE LEONID SHOWER.

Nov. 15, 1899, 20^h—23^h Greenwich M. T., by Miss Anne S. Young and students at Mt. Holyoke College Observatory, Mt. Holyoke, Mass.

No. on Chart.	Time. h	m	No. on Chart.	Time. h	m	No. on Chart.	Time. h	m
1	14	27	8	16	25	15	16	50
2	15	29	9	16	32	16	16	52
3	15	40	10	16	33	17	17	08
4	15	49	11	16	40	18	17	14
5	15	57	12	16	42	19	17	14
6	16	08	13	16	44	20	17	16
7	16	21	14	16	44	21	17	40

SPECTROSCOPIC NOTES.

A summary is given, in *Science* for Nov. 10, of the forthcoming Report of the Director of the Lick Observatory to the President of the University of California for the year ending Sept. 1, 1899. The 36-inch refractor, in charge of Professor Campbell, is devoted about half the time to spectroscopic work; notably to the determination, by Professor Campbell assisted by Mr. Wright, of motion of stars in the line of sight. In this work they have secured such a degree of accuracy that they are able to determine the motion of a star with an error not greater than a fourth of a kilometer (a sixth of a mile) per second. During the year 522 spectrograms were secured, and about 200 definitely measured. Of stars showing a variable velocity in the line of sight there were 15; among them Polaris, which seems to be a spectroscopic triple, and Capella, which gives a composite spectrum. A plea is made, surely not an unreasonable one, for the appointment of another assistant in this branch of the work of the Observatory.

The 36-inch has also been used by Mr. Wright to photograph and to observe visually the spectra of such comets as were bright enough, and by the Director, Professor Keeler, in his work on the spectra of nebulae, especially the nebula of Orion.

The Crossley reflector, in immediate charge of the Director, has been used chiefly in photographing nebulae. A comparison of the photographs of the nebula of Orion on isochromatic and on ordinary plates has indicated that the light of the nebula is not uniform in character throughout its whole extent.

Mr. Espin describes in the *Astrophysical Journal* for October his investigation of the distribution with reference to the milky way of the variable stars of Secchi's type III. Using only those stars of this type whose variation is considerable and whose hydrogen lines are bright, he finds that they, like the stars of type IV, are distinctly related to the milky way. While stars of type IV are most numerous near the galactic equator, the variable stars of type III are found to be most thickly distributed along the borders of the milky way; and while the type IV stars are distributed pretty evenly in galactic longitude, the type III variables show a distinct tendency to form into groups.

In the *Astrophysical Journal* for October Professor Campbell gives—a little tardily, when it is remembered that the eclipse occurred as long ago as January 1898—his results, from photographs taken at the last eclipse in India, for the wave-length of the corona line. He confirms completely Sir Norman Lockyer's discovery that the corona line is not at all the strong chromosphere line at λ 5317 (the famous Kirchhoff 1474) with which it has so long and so strangely

been supposed to be identical, but is really more than twice the width of the D lines away, at λ 5303. Professor Campbell used a train of six prisms, giving a deviation for the corona line of 265°; collimator lens and camera lens, each of about 2 inches aperture and 20 inches focal length, and before the spectroscope a small object-glass of the same dimensions, forming on the slit an image of the corona about a fifth of an inch in diameter. His final result is, for the wave-length of the corona line, 5303.26; for the velocity of rotation of the inner corona 3.1 kilometers (2.0 miles) per second, uncertain, however, by at least 2 km. (1.2 mi.) per second.

Mr. Bigelow has collected data with reference to the prospect of clear weather for the eclipse of May 28, 1900, along the narrow path of totality from New Orleans to Norfolk. His table, compiled from observations in recent years, indicates clearly that good weather is much more probable at the higher stations in the interior than at the less elevated stations near the Atlantic coast on one side or the Gulf coast on the other.

In the *Astrophysical Journal*, October, Professor Frost states that, finding iron inconvenient as the element yielding the comparison spectrum for his star spectra, on account of the scarcity of iron lines in the part of the spectrum employed, he has successfully used titanium. This metal is easily manipulated, and its choice seems especially fortunate from the fact that in the spectra of the important type I b nearly every line in the part of the spectrum used falls close to a sharp titanium line.

Mr. Wright gives, in the *Astrophysical Journal* for October, his observations at the Lick Observatory on the spectra of four comets. Observing visually he found in the spectra of the comets 1898 I and 1898 VII the usual three carbon bands with the continuous spectrum relatively strong, and in the spectra of the comets 1898 X and 1899*a* the three bands with the continuous spectrum relatively weak. The spectrum of 1899*a* was bright enough to yield a valuable photograph.

In the *Astrophysical Journal* for October Professor Campbell announces that he finds variable velocity in the line of sight in the case of no less than five stars, ε Librae, *h* Draconis, λ Andromedae, ε Ursae Minoris, and ω Draconis.

In the same number Professor Campbell gives his measures in detail showing Polaris to be a spectroscopic triple, and Professor Frost gives the results of plates taken at the Yerkes Observatory, confirming this result so far as to show that Polaris is at least double.

Professor Campbell finds Capella, unlike the majority of his spectroscopic binaries, to be a binary in which both components are visible. One component gives a spectrum strictly of the solar type, the other a spectrum containing the *Hγ* line of hydrogen and the more prominent iron lines. The lines of the latter spectrum are shifted, sometimes to the violet, sometimes to the red, with reference to the lines of the former; indicating orbital motion of the components.

VARIABLE STARS.

J. A. PARKHURST.

Minima of the Variable Stars of the Algol Type.

(Given to the nearest hour in Greenwich Time.)

1900.

U CEPHEI.

	d	h
Jan.	2	9
	4	21
	7	9
	9	21
	12	9
	14	20
	17	8
	19	20
	22	8
	24	20
	27	8
	29	19

W DELPHINI.

	d	h
Jan.	15	8
	29	18

ALGOL.

	d	h
Jan.	1	11
	4	8
	15	19
	18	16
	21	12
	24	9
	27	6

λ TAURI.

	d	h
Jan.	7	22
	11	21
	15	19
	19	18
	23	17
	27	16
	31	15

S CANCRI.

	d	h
Jan.	8	8
	17	20
	27	7

R CANIS MAJ.

Every 8th min.
$P = 1^d\ 3^h.3$

	d	h
Jan.	0	17
	9	19
	18	21
	27	23

δ LIBRAE.

	d	h
Jan.	7	19
	14	19
	21	18
	28	18

S VELORUM.

	d	h
Jan.	7	2
	13	1
	18	23
	24	22
	30	20

U CORONAE.

	d	h
Jan.	1	18
	8	15
	19	0
	25	22

DM + 45°3062

	d	h
Dec.	0	6
	13	23

NOTES.

NO EPHEMERIS of Variable stars for 1900 has appeared at this writing, so the long period stars must be left till next month. The above Algol-type ephemeris was computed from the elements given in Chandler's third catalogue and supplements, except for Ceraski's new variable, DM. + 45°3062 which is based upon Professor Pickering's elements given in Harvard College Observatory Circular No. 44.

SAWYER'S ALGOL-TYPE VARIABLE + 12°3557. Since the writing of the note in regard to this star in the November number, page 492, a confirmation of its variability has been published by M. M. Luizet, of the Lyons Observatory in No. 3596 of the *Nachrichten*. From 117 measures he has found the duration of normal light to be $17^h\ 28^m$, the decrease occupies $1^h\ 58^m$, and the increase $1^h\ 55^m$. The variation is from about 7.2 to 7.7 magnitude, on the light scale used by M. Luizet. The period given by Mr. Sawyer in *Astronomical Journal* No. 450 proves to be about half a minute too long: M. Luizet gives as the elements of minimum—

1898 Oct. 3 $13^h\ 10^m$ (Paris M. T.) + $21^h\ 20^m.5$ E.

It is possible that a few minima may be observed early in December, by the above elements they are due as follows—

Epoch.	Gr. T.
478	Dec. 2^d 15^h
479	3 12
487	10 15
488	11 12
496	18 15
497	19 13

For chart and position see Vol. VI. page 581 of this journal.

DISTRIBUTION OF VARIABLE STARS.—In the *Astrophysical Journal* for October, 1899, Rev. T. E. Espin has given some tables showing the distribution of the stars of Type IV and the variable stars of Type III, with reference to the Milky Way. Starting from the medial line of the Galaxy parallels were drawn at every 10 degrees of Galactic latitude and a count was made of the number of stars in each of the zones thus formed. The following table shows the results for the variable stars of Type III excluding those where the variation was small and the hydrogen lines not bright.

TABLE I.

Gal. lat.	N. lat.	S. lat.	Total.
0°-10°	25	23	48
10 -20	29	25	54
20 -30	32	33	65
30 -40	17	29	46
40 -50	10	14	24
50 -60	17	15	32
60 -70	10	3	13
70 -80	1	4	5
80 -90	1	5	6
Total	142	151	293

Rev. Espin remarks—"This table seems to show that the variable stars have a tendency to collect on the borders of the Milky Way." It is hard to say to what extent conclusions of this kind are justifiable. If all, or nearly all the varibles were known, such a table might be used as a basis for search for a physical cause for the peculiarity of distribution, but as a fact the discovery of variables proceeds at an undiminished rate, and the grouping may disappear when our knowledge is more complete. In one particular, however, the above table might be misleading, since it takes no account of the areas of the different zones, and on the face seems to show a remarkable scarcity of variables near the Galactic poles. A better idea of the distribution can be had by considering, instead of the actual number of stars, the number per unit of area, which may be termed the density of distribution.

TABLE II.

Gal. lat.	Total.	Area.	Density.
0°-10°	48	0.174	273
10 -20	54	0.168	321
20 -30	65	0.158	411
30 -40	46	0.143	322
40 -50	24	0.123	195
50 -60	32	0.100	320
60 -70	13	0.074	176
70 -80	5	0 045	111
80 -90	6	0.015	400

In Table II the second column gives the total number as in the last column of Table I, the third column gives the areas of the zone, taking the hemisphere as

unity, and the last column, headed "Density," gives the quotient of the number of stars divided by the area, or the number of stars on a hemisphere if they occurred as frequently as in the particular zone. It appears from this table that the inequality of distribution is not nearly as great as would appear from a superficial view of Table I, and the scarcity near the Galactic pole disappears, in fact the variable stars occur more frequently in the zone 80°-90° than in any other zone except 20°-30°.

ANDERSON'S TWO NEW VARIABLES.—These were announced in No. 3594 of the *Nachrichten*, the notes being dated 1899 Sept. 18 and 21.

The first is a star in Hercules, not in the Durchmusterung, place estimated by the discoverer

R. A. $17^h\ 53^m\ 27^s$ Decl. $+19°\ 30'$ (1855)

Aug. 22 and 24 the variable was 9.0 mag., Sept. 17, 9.9 mag. I found it about 11¼ mag. Oct. 12, followed by a decline to 12½ mag. Nov. 4. Micrometric comparisons with B. D. $+19°3489$ and 3494 (which are in the Berlin A *Astronomische Gesellschaft* Catalogue) give the place—

R. A. 17^h	53^m	27.7^s	Decl. $+19°$	$29'$	$41''$ (1855)
	55	24.7		29	20 (1900)

The fall of 3½ magnitudes in 10 weeks marks this as one of the comparatively rapid long-period variables.

The second discovery (not in the DM.) was estimated by Rev. Anderson as 8.5 mag. 1899 Aug. 28: 8 6 Aug. 31 and 9 2 Sept. 20, with the place—

R. A. $20^h\ 9^m\ 44^s$ Decl. $+30°\ 37'$ (1855)

The variation of this star is much slower than the preceding, as I found it 9.3 mag. Oct. 12, and 9.7 Nov. 8. Its place from micrometer measures is—

R. A. 20^h	9^m	$44\ 4^s$	Decl. $+30°$	$37'$	$54''$ (1855)
	11	32 6		46	1 (1900)

The Galactic latitudes of these two new variables are $+17°$ and $-3°$ respectively.

SS CYGNI.—The maximum just past was a "short" one, according to the order which the star has followed for the last two years. The beginning of the rise was caught by Mr. Zaccheus Daniel (at Bucknell Observatory Lewisburg, Pa.,) and myself, each finding the star 10.9 magnitude, 0.4 above normal, Oct. 24.6 Gr. T. It was found at 8.65 magnitude by Mr. David Flanery Oct. 25.6, so the time of rise was well fixed. The number of observations at hand at this writing are as follows—

Zaccheus Daniel	8
David Flanery	6
J. A. Parkhurst	11
W. E. Sperra	2
P. S. Yendell	3
	30

The principal features of the maximum are—

Previous normal period		44^d
Rise began	1899 Oct.	24 .2
Passed 9.35 mag	Oct.	25 .0
Maximum, (8.5 mag.)	Oct.	26 .8
Reached normal	Nov.	5 .6
Above normal		$12\ .4^d$

The following table shows the intervals which have elapsed between the successive maxima of the same kind, since April 1897—

Epoch	Short Max.	Long Max.
0–1	$106^d.4$	$115^d.8$
1–2	114 .1	111 .0
2–3	110 .5	120 .6
3–4	121 .4	110 .6
4–5	113 .7	123 .4
5–6	116 .5	115 .0
6–7	116 .4	114 .2
7–8	115 .0	113 .2

It appears from this that the maxima are following each other with greater regularity than formerly, and with a mean period somewhat shorter than in 1898.

PLANET NOTES FOR DECEMBER.

H. C. WILSON.

Mercury will be at inferior conjunction Dec. 5 and so will not be visible to the eye during the first half of the month. On the 25th Mercury will reach greatest elongation west of the Sun, 22° 11′, and for a few days about that time the planet will be visible as morning star. Mercury will be in conjunction with Uranus twice during the month, passing by the latter planet on the morning of Dec. 10 going westward and again on the 22nd going eastward.

Venus is "evening star" but is not far enough from the Sun yet to be very noticeable. Her low altitude is also to her disadvantage in this latitude. She can be seen toward the southwest only a short time after sunset.

Mars is also "evening star" but is closer to the Sun than Venus so that he cannot be seen at all with the naked eye.

Jupiter is morning star and may be easily seen toward the southeast by early risers. He is entering the constellation Scorpio and is at such a low altitude at best that no satisfactory observations can be obtained.

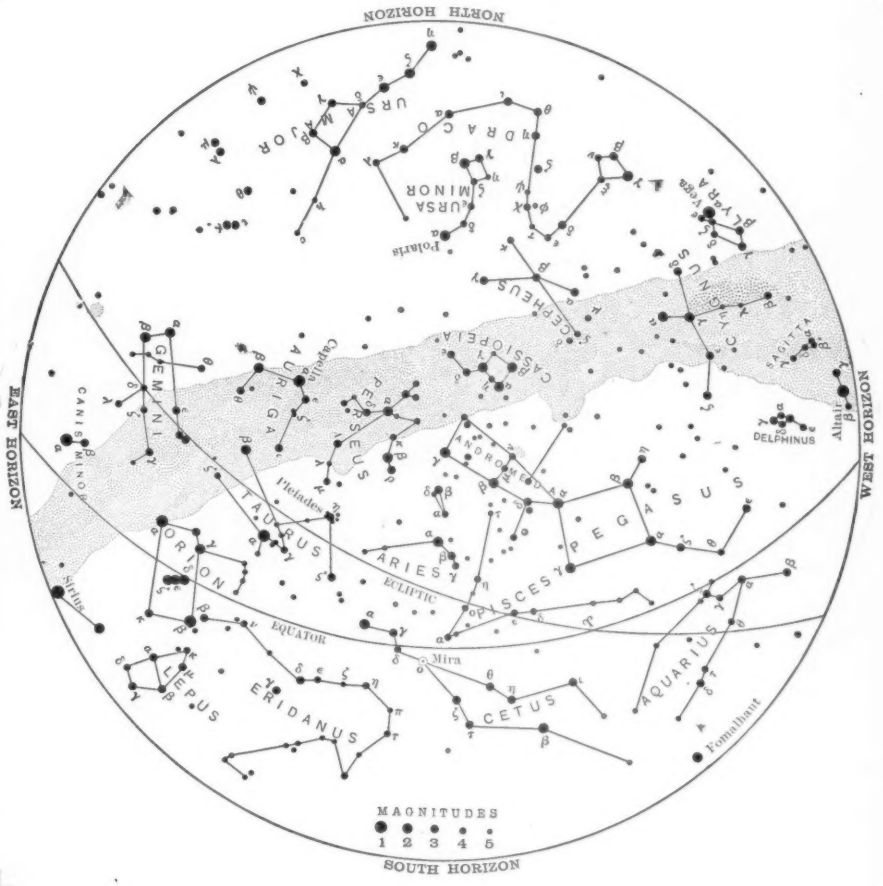
Saturn will be in conjunction with the Sun Dec. 17 and so is out of view for this month.

Uranus is just past conjunction and is therefore too close to the Sun to be observed.

Neptune is in the opposite part of the heavens to all the other planets and in best position for observation. Opposition occurs on Dec. 17, the same day on which Saturn is at conjunction Neptune, unfortunately for amateur observers, cannot be seen without a telescope and can be distinguished as a planet by its disc only with quite powerful telescopes. Its motion is very slow among the faint stars between ζ Tauri and η Geminorum.

The Moon.

		Phases.	Rises. (Central Standard Time at Northfield; Local Time 13m less.)		Sets.	
			h	m	h	m
Dec.	2	New Moon	7	14 A. M.	4	15 P. M.
	9	First Quarter	12	3 P. M.	12	32 A. M.
	16	Full Moon	4	22 "	8	13 "
	24	Last Quarter	14	33 A. M.	11	51 "



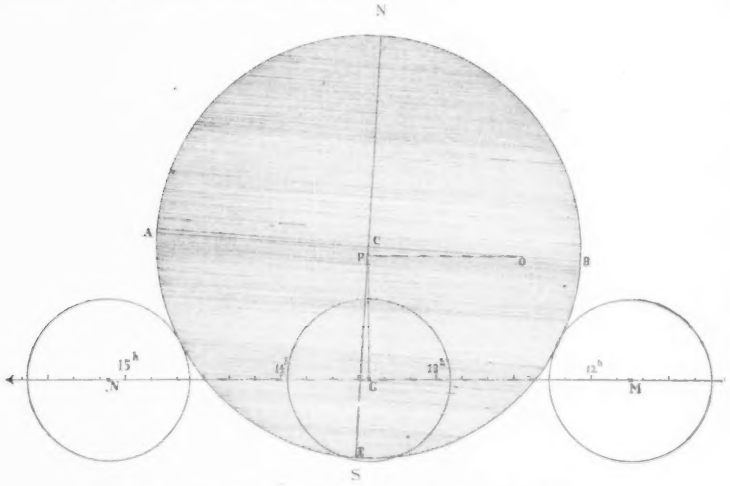
THE CONSTELLATIONS AT 9 P. M., DECEMBER 1, 1899.

Occultations Visible at Washington.

Date. 1899.		Star's Name.	Magnitude.	IMMERSION. Washington M. T. h	m	Angle f'm N pt. °	EMERSION. Washington M. T. h	m	Angle f'm N pt. °	Duration. h	m
Dec.	6	π_1 Capricorni	7.0	7	30	86	8	25	223	0	55
	6	π_2 Capricorni	5.6	8	27	93	9	16	219	0	49
	8	51 Aquarii	5.8	6	35	8	7	24	286	0	49
	14	A^1 Tauri	4.6	15	5	91	16	6	272	1	1
	14	A^2 Tauri	6.3	15	24	106	16	22	256	0	58
	21	14 Sextantis	6.6	15	56	174	16	54	255	0	58
	23	ε Leonis	5.3	12	16	158	13	7	236	0	51

Partial Eclipse of the Moon, Dec. 16, 1899.—This will be visible in the United States and generally throughout North and South America, Europe and Africa. The beginning will not be visible in the extreme western part of North America. In Asia only the beginning will be visible.

At Northfield the Moon will rise about an hour and twenty minutes before it touches the umbra of the Earth's shadow. The accompanying diagram shows the motion of the Moon relative to the Earth's shadow during the eclipse. The large shaded circle represents the Earth's shadow and the smaller circle the Moon at the three moments, of beginning, middle and end of the eclipse. The line *MN* indicates the path of the Moon's center, and upon it is marked the position of the Moon's center at every 10^m of Greenwich mean time. Central Standard time is obtained by subtracting 6 hours or Eastern Standard time by subtracting 5 hours from Greenwich time.



PARTIAL ECLIPSE OF THE MOON, DEC. 16, 1899.

The shaded circle represents the Earth's shadow; the smaller circles, the Moon. The hours marked on the diagram are Greenwich mean time.

The eclipse will be very nearly total at the middle, only the south edge of the Moon's disc emerging from the shadow. The *American Ephemeris* gives the magnitude of the eclipse as 0.996 of the Moon's diameter, but the diagram makes it a little less.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of conjunction in right ascension Dec. 16, 13^h 29^m 0^s.4.

Sun's right ascension	17^h	37^m	54^s.97	Hourly motion	11^s.08
Moon's right ascension	5	37	54 .97	Hourly motion	139 .17
Sun's declination	− 23°	21′	16″.3	Hourly motion	− 0′ 5″.9
Moon's declination	+ 22	55	37 .3	Hourly motion	− 1 43 .2
Sun's equa. hor. parallax			8 .9	Sun's true semi-diameter	16 15 .5
Moon's equa. hor. parallax		56	10 .6	Moon's true semi-diameter	15 17 .7

TIMES OF THE PHASES.

	Greenwich M. T.			Central Standard Time.		
		h	m	h	m	
Moon enters penumbra	Dec. 16	10	32.9	4	32.9	P. M.
Moon enters shadow		11	44.9	5	44.9	"
Middle of the eclipse		13	26.0	7	26.0	"
Moon leaves shadow		15	6.7	9	6 7	"
Moon leaves penumbra		16	18.8	10	18.8	"

Six New Asteroids —These were discovered photographically by Wolf and Schwassman at Königstuhl on the nights of Oct. 27, 31 and Nov. 4. Their positions were as follows:

		Konigstuhl M. T.			R. A.			Decl.			Daily Motion.		Mag.
			h	m	h	m	s	°	′		′	″	
1899	ER	Oct. 27	11	1.5	1	35	24	+ 5	15		− 14	0	11.0
	ES	27	11	1.5	1	42	48	+ 5	13		− 12	3	11.3
	ET	27	11	1.5	1	40	0	+ 6	40		− 12	− 0	11.5
	EU	31	8	55.7	1	18	36	+ 3	44		− 14	− 2	11.0
	EV	31	12	48.8	1	56	12	+ 17	44		− 14	− 1	11.7
	EW	Nov. 4	13	24.0	1	57	0	+ 8	6		− 13	− 2	11.0

The fifth of these, 1899 *EV* is possibly (214) Aschera but the identification is very uncertain.

COMET NOTES.

Ephemeris of Comet *c* 1899 (Giacobini).

[From *Astronomische Nachrichten*, No. 3600].

		R. A.			Decl.		log *r*.	log Δ	Brightness.
		h	m	s	°	′			
Dec.	2	18	7	36	+ 12	47.4	0.3118	0.4286	0.45
	3		9	18	13	4.4			
	4		11	0	13	21.4			
	5		12	42	13	38.5			
	6		14	24	13	55.7	0.3171	0.4325	0.43
	7		16	7	14	13.0			
	8		17	50	14	30.4			
	9		19	33	14	47.8			
	10		21	17	15	5.4	0.3224	0.4362	0.41
	11		23	0	15	23.0			
	12	18	24	44	+ 15	40.7	0.3251	0.4380	0.40

Ephemeris of Comet Holmes 1899 II (*d* 1899).

	1889	α app.			δ app.			*r*	log Δ
		h	m	s	°	′	″	Δ	
Dec.	1	2	8	24.88	+ 46	36	25.1	0.01032	0.252226
	2		7	53.24	46	27	54.2	01036	254215
	3		7	23.83	46	19	18.2	01041	256247
	4		6	56.65	46	10	37.7	01046	258320
	5		6	31.72	46	1	53.4	01051	260434
	6		6	9.05	45	53	5.9	01056	262587
	7		5	48.62	45	44	16.0	01062	264777
	8		5	30.45	45	35	24.2	01067	267004
	9		5	14.52	45	26	31.2	01073	269267
	10		5	0.82	45	17	37.6	01079	271563
	11		4	49.35	45	8	43.8	01084	273892
	12		4	40.08	44	59	50.6	01090	276253
	13		4	32.99	44	50	58.3	01096	278643

1899	α app. h m s	δ app. ° ′ ″	τ d	log Δ
14	4 28.08	44 42 7.4	01102	281064
15	4 25.30	44 33 18.5	01109	283512
16	4 24.65	44 24 31.9	01115	285987
17	4 26.10	44 15 48.1	01121	288488
18	4 29.63	44 7 7.4	01128	291014
19	4 35.21	43 58 30.2	01135	293563
20	4 42.83	43 49 57.0	01141	296135
21	4 52.45	43 41 27.9	01148	298728
22	5 4.05	43 33 3.5	01155	301342
23	5 17.60	43 24 43.9	01162	303975
24	5 33.09	43 16 29.4	01169	306627
25	5 50.48	43 8 20.5	01176	309292
26	6 9.76	43 0 17.2	01184	311982
27	6 30.88	42 52 19.8	01191	314683
28	6 53.84	42 44 28.7	01199	317398
29	7 18.59	42 36 43.9	01206	320127
30	7 45.12	42 29 5.8	01214	322868
31	8 13.40	42 21 34.4	01222	325621
32	2 8 43.41	+ 42 14 10.0	0.01229	0.328384

GENERAL NOTES.

This number closes Volume VII of this publication. From the interest that some of our friends are taking in our work it is probable that POPULAR ASTRONOMY will soon be considerably enlarged. This step will certainly be made possible if our present subscribers will aid us by prompt renewals and help us to increase our list.

Reports from Leonid Observers.—We have been favored by subscribers and other friends who have already sent us useful observations and charts of the November Leonids which will appear in our January issue. Much of the work was well done.

A Question as to Meteoric Showers.—In view of the fact that there were showers of meteors in November 1799; and in November, 1831, 1832, 1833; and again in November, 1866, 1867, 1868; ought we not to expect showers in November, 1901, 1902, 1903; or, using the period between 1799 and 1831 as a basis, ought we to expect showers in 1900, 1901, 1902?

TURNER'S FALLS, MASS., ANGELO HALL.
1899, Nov. 21.

A Shower of Bielids.—A well marked, but not specially conspicuous, shower of Bielid meteors was observed here last night (Nov. 24th) between half past nine and eleven o'clock $14^h\ 30^m$ to 16^h, G. M. T. For a short time about ten o'clock the meteors observable by a single person averaged two or three a minute. Between ten and eleven I counted 42,—three quarters of them in the first half hour; and two persons standing by during the early portion of that time saw fully as many more in addition to those seen by me. After eleven o'clock I saw only three meteors in fifteen minutes, and discontinued the observations. I judge that the shower began between quarter and half past nine from the report of two observers, who counted ten meteors in less than five minutes about 9:30, while half an hour earlier, during a watch of ten minutes, I myself saw only one, and concluded that there was no use in keeping up the lookout.

The meteors were mostly small, but about a dozen were brighter than the second magnitude, and two or three rivalled Sirius. They all left trains, which were evanescent,—not persistent for some seconds like those of Leonids.

Only four meteors appeared very near the radiant, so that it was difficult to determine its position with accuracy; but I estimate that at 10:30 its centre was situated about half way between Chi and Upsilon Andromedæ:—approximately in R. A. $1^h\ 32^m$, and Decl. $+\ 42°\ 15'$. It was obviously not a point, but an area two or three degrees in diameter.

The sky was brilliantly clear, but the numerous electric lights in the neighborhood were very troublesome, and doubtless considerably reduced the number of meteors observed.

C. A. YOUNG.

PRINCETON, N. J.
Nov. 25, 1899.

Laboratory Methods in Elementary Astronomy.—From letters received regarding the article published last month, on astronomy by the laboratory method in secondary schools, we notice the interest in this matter already anticipated. Possibly others may wish to communicate with the author for further information, if so address Professor Herbert Brownell, The Nebraska State Normal and Training School, Peru, Nebraska.

Indiana University.—In a recent letter from Professor John A. Miller, we learn that the Board of Trustees of Indiana University at Bloomington, Ind., have ordered the purchase of a 12-inch refractor and the erection of an astronomical Observatory. This new Observatory will be called the Kirkwood Observatory in honor of Dr Daniel Kirkwood. This is a most fitting memorial to the memory of a noble man who spent 30 of the best years of his life as a member of the Faculty of Indiana University.

The Leonid Meteors at Princeton.—In a private letter of Nov. 25, Professor C. A. Young says: The night of Monday–Tuesday (14–15) was rainy. On Tuesday night it cleared up soon after midnight and remained clear until 5 A. M. —only about 20 Leonids were seen, and on the five photographic plates exposed, at two different stations, not a single meteor trail was caught.

A Brilliant Meteor.—Under date of Nov. 21, Eleanor B. Drake, of Chicago, has furnished a very interesting account of observations made at Morgan Park, Ill. Though communicated in a private letter, we take the liberty of publishing part of it: She says: "Enjoying as we do, a home upon the highest ridge of ground in Cook county, I have had a chance of making nightly observations for the past six years.

"During the display of the Perseids, our view of them was superb, a party of us watching them far into the night. On the night of the 13th of Nov., with many other Chicago star gazers, I met with complete disappointment. But on the 14th the Moon rose in a clear sky at 4 P. M. I kept a constant watch until 8 P. M., when there having appeared a lake fog rising slowly from the eastern flats. Stepping out on a west I porch commenced a careful survey of Cygnus and Lyra. I was startled by a magnificent train of fire sweeping in its *curve* from the meridian downward through the space between the upright Cross and Lyra and bursting in a ball of wondrous color on a line about with the lower star in Cygnus and our beautiful evening star Vega which paled in lustre beside

the wanderer. I think that the meteor was about three times as large as a first magnitude star."

November Meteors.—The time of appearance of the November meteors is somewhat uncertain. In 1799, they appeared on the night between November 11 and 12. In 1833 on November 12-13, and in 1866, on November 13-14. This year we might therefore expect them early in the morning of Wednesday, November 15. On the other hand, two English astronomers, Messrs. Stoney and Downing, from a careful discussion of the paths of these meteors predict their appearance on the morning of Thursday, November 16. In 1833 the principal shower lasted five or six hours; in 1866 for less than an hour. In any case, comparatively few meteors may be expected before midnight. It would be safest, therefore, to watch the north eastern sky on both Tuesday and Wednesday evenings, and, if many meteors are seen before midnight, a greater number may be expected later. EDWARD C. PICKERING.

November 11, 1899.

Maximum of *o* Ceti (Mira) in 1899.—The small range of variation in *o Ceti* during the past season was in marked contrast to the brilliant maximum of last year.

July 7.—On a dark sky Mira was brighter than adjacent star to the north classed as 7.8 in the Durchmusterung chart, POP. AST. No. 52, and dimmer than *71 Ceti*

" 22.—Brighter than *71* and equal to *69 Ceti* in full moonlight.

" 30.—Brighter than *69*. Half moon not far.

August 13.—On dark sky equal to ξ *Piscium* in lustre but redder in tint.

" 19.—Half magnitude less than δ *Ceti*. Full moonlight.

" 22.—About one-fourth magnitude less than δ in nearly full moonlight.

" 30.—In hazy atmosphere it seems dimmer than δ.

September 5.—Less than δ, probably a half magnitude, where near meridian on a dark sky.

" 14.—Midnight. In the light of the gibbous moon brighter than δ, but at 3 a. m. when the moon had set it seemed scarcely so bright. The difference of tint was probably the cause of this, as white stars pale in moonlight.

" 26.—Very nearly as bright as δ on a dark moonless sky.

October 1.—No moonlight. It is half a magnitude less than δ, which indicates an unusually rapid decrease in six days.

" 2.—A half magnitude less than δ on a moonless sky.

" 3.—Ditto on a clear dark sky.

" 8.—Slightly brighter than ξ *Piscium*. No moonlight.

" 13.—Equal to ξ *Piscium*.

" 18.—Slightly less in moonlight.

" 24.—Slightly less on a clear dark sky. ROSE O'HALLORAN.

SAN FRANCISCO, Oct. 27, 1899.

Errata.—On page 419 the following corrections should be made: Lines 3 and 4 from the top, for when $d' = b$, read $d' = 6$. Line 3 from top, for $c = 20 -$, read $c = 30 -$. Line 2 from bottom, for $R_9\ N = R_9$ read $R_9 N = R_9$.

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